

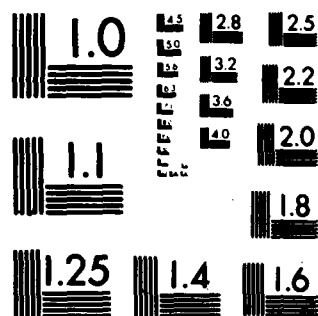
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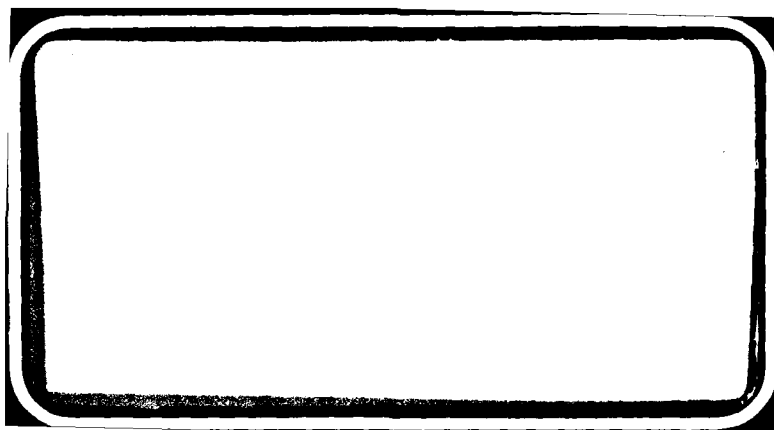
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THE MOVEMENT OF SOFT CONTACT LENSES
ON THE HUMAN EYE
EXPOSED TO + G_z ACCELERATION

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ABSTRACT

Aircrew in the Canadian Forces who require optical correction are required to wear conventional spectacles. The use of contact lenses would alleviate many problems posed by eyeglasses. Concern has been expressed that contact lenses may slip excessively, or be lost from the eye under conditions of increased +Gz.

Experienced contact lens wearers were exposed to +Gz in the DCIEM centrifuge. Each subject was wearing a pair of 15 mm soft contact lenses. Each lens was marked with a 12 mm white cross to facilitate observation of movement. Movement of the lenses was filmed with a high-speed LOCAM camera with telephoto lens. The resulting film was projected and the magnified movement along the -z axis was measured using the iris as a reference. These measurements were then corrected to real values. Each subject was examined with a slit lamp before and after +Gz exposures for objective evaluation of fit and movement of the lenses.

It was observed that the soft contact lenses were displaced along the -z axis with increasing +Gz in most cases. After being displaced at peak G the lenses did not immediately return to their original position with reduction of G. It was further observed from the film that at no time was lens slippage great enough to prevent a subject from receiving optical correction. The amount of slippage between subjects is highly variable. Blinking action and facial tensing also affect the amount of movement.

It has been confirmed that standard 15 mm HEMA soft contact lenses are suitable for aircrew who do not experience more than 5.1 +Gz at eye level.

INTRODUCTION

Soft contact lenses have been suggested for use by military aviators in an effort to avoid problems presented by conventional spectacles. Some of the many problems which the use of contact lenses partially alleviate are:

- a. Fogging of lenses during cold weather operations.
- b. Glare from light reflection off the back of spectacle lenses.
- c. Interference of the visual field due to debris collecting on lenses.
- d. Interference of the visual field due to frames.
- e. Interference of lenses and frames with scopes, binoculars and sighting devices.
- f. Interruption of the ear cup seal of helmets with subsequent degradation of hearing protection.
- g. Poor interfacing of spectacles and oxygen mask.
- h. Poor compatibility with chemical warfare respirators.

By avoiding many of the above mentioned drawbacks, the efficiency of aircrew can be improved and hence a tactical advantage achieved.

As part of an evaluation of the role of soft contact lenses in the Canadian military environment, a study was undertaken to determine if clinically significant displacement of soft contact lenses occurred in subjects exposed to +Gz forces. Similar work has been reported but with failure to quantify the movement of the lenses (2, 3, 4).

METHOD

Six healthy male volunteers were fitted with soft contact lenses and exposed to +Gz forces in the Defence and Civil Institute of Environmental Medicine (DCIEM) human centrifuge.

The lenses used were lathe-cut lenses of hydroxyethyl-methacrylate (HEMA) having a water content of 40 per cent and refractive index of 1.4.

A large white cross was incorporated into the lens material during manufacture to facilitate exact determination of its position

on the eye.

All lenses were 15 mm in diameter with an optical zone of 13 mm diameter and base curve of 9 mm radius. The base curve was slightly flatter than the curvature of the lenses normally worn by the subjects and consequently a loose fit was obtained in all cases.

While wearing these contact lenses, all volunteers were given one exposure to 5+Gz. Subjects not displaying unacceptable discomfort were given an additional exposure to 6+Gz. These levels were measured at mid gondola level and calculation of eye level +Gz was made using a sitting seat to eye distance of 31 inches.

The acceleration was applied at a rate of onset of approximately 0.5 G per second and the peak acceleration held for 3 to 8 seconds. Exact values for eye level G and onset rates is presented in Table 1.

Movement of the contact lenses was filmed using a LOCAM camera fitted with a telephoto lens run at a rate of 200 frames per second. The processed films were projected and the magnified displacement of lenses was measured along the physiological z axis using the iris as a reference. The position of the lens at 1 G, prior to each run, was used as the origin for measurements in each run. The magnified values of displacement were then corrected to real values.

Each measurement was subjectively graded as "usable", "poor", "fair", "good", "very good" or "excellent". The criteria for assigning a grade was the accuracy with which a measurement could be made on the projected image of the lens.

The means and standard deviations were calculated for all data and selected data graded "good" or "better".

DISCUSSION

Usable data was obtained from 18 eyes. In 12 eyes the data related to the 5G runs (peak eye level G of 4.2) and in 6 eyes to the 6G runs (peak eye level G of 5.1).

Figures 1 and 2 present the 5 G runs (peak eye level G of 4.2) and Figures 3 and 4 present the 6 G runs (peak eye level G of 5.1).

It was observed that the soft contact lenses were displaced along the z axis during the +Gz exposures. In four of the 18 eyes there was an upward displacement of the lens of from 0.3 mm to 0.8 mm at some time during the run, generally at the time of maximum G stress and probably explained by lid tightness, squeezing and blinking. In fourteen of the eighteen eyes, there was downward displacement of the lens which varied from 0.1 to a maximum of 3.4 mm. The amount of lens displacement between subjects was highly variable and affected by blinking, facial tensing and lid tightness but in no subject was the slippage sufficient to leave the pupil uncovered by the optical zone

of the lens.

A close examination of the data by group confirms the role of blinking, facial tensing and lid tightness in reducing the amount of lens slippage. All subjects for the experiment were instructed to hold their eyes wide open during the course of the G exposure in order to obtain usable photographs. Those exhibiting a high degree of self control and relative comfort with G were able to do this successfully. These will be referred to as "non-blinkers". Others were less successful and will be referred to as "blinkers".

Figure 1 (All Data for 5 G Runs) illustrates a typical exposure. The lens moves down with increasing G and continues its movement down while at peak G until a maximum is reached. With G offset the lens coincidentally moves up but does not return to the original position until the subject blinks. This group of subjects was a mixture of "blinkers" and "non-blinkers".

Figure 3 (All Data for 6 G Runs) was obtained from those subjects who could demonstrate good self control in the centrifuge and as such were primary "non blinkers". Without blinking and face tensing, the lens descends with increasing G and tends to level off and remain constant shortly after peak G, but does not return upon offset of G. The lenses did return to their normal position with blinking after the exposure.

The examination of data graded "good" or "better" (Figures 2 and 4) shows the same pattern of movement with greater confidence in the accuracy of measurements. Observing the individual films of "blinkers" and "non-blinkers" confirms this observation.

CONCLUSIONS

Soft contact lenses descend on the eye with increasing +Gz. The amount of slippage is affected by G, blinking, facial tensing and lid tightness. At no time was lens slippage great enough to prevent the subject receiving optical correction.

Standard 15 mm diameter HEMA soft contact lenses are suitable with respect to +Gz acceleration for use by aircrew who do not experience more than +5.1 Gz at eye level.

ACKNOWLEDGEMENTS

The authors would like to thank Sergeant B.P. Mailey for his efforts in obtaining the films used in this experiment.

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Table 1

RUN	G ONSET RATE (EYE LEVEL) G/sec	MID GONDOLA + G _z	EYE LEVEL + G _z
5 G	.45	1	1
		2	1.8
		3	2.6
		4	3.4
		5	4.2
6 G	.54	1	1
		2	1.8
		3	2.6
		4	3.4
		5	4.2
		6	5.1

Onset rates and calculated eye level +G_z
for specific mid gondola +G_z.

Figure 1

DISPLACEMENT OF CONTACT LENSES WITH $+G_z$

All data for 5 G runs

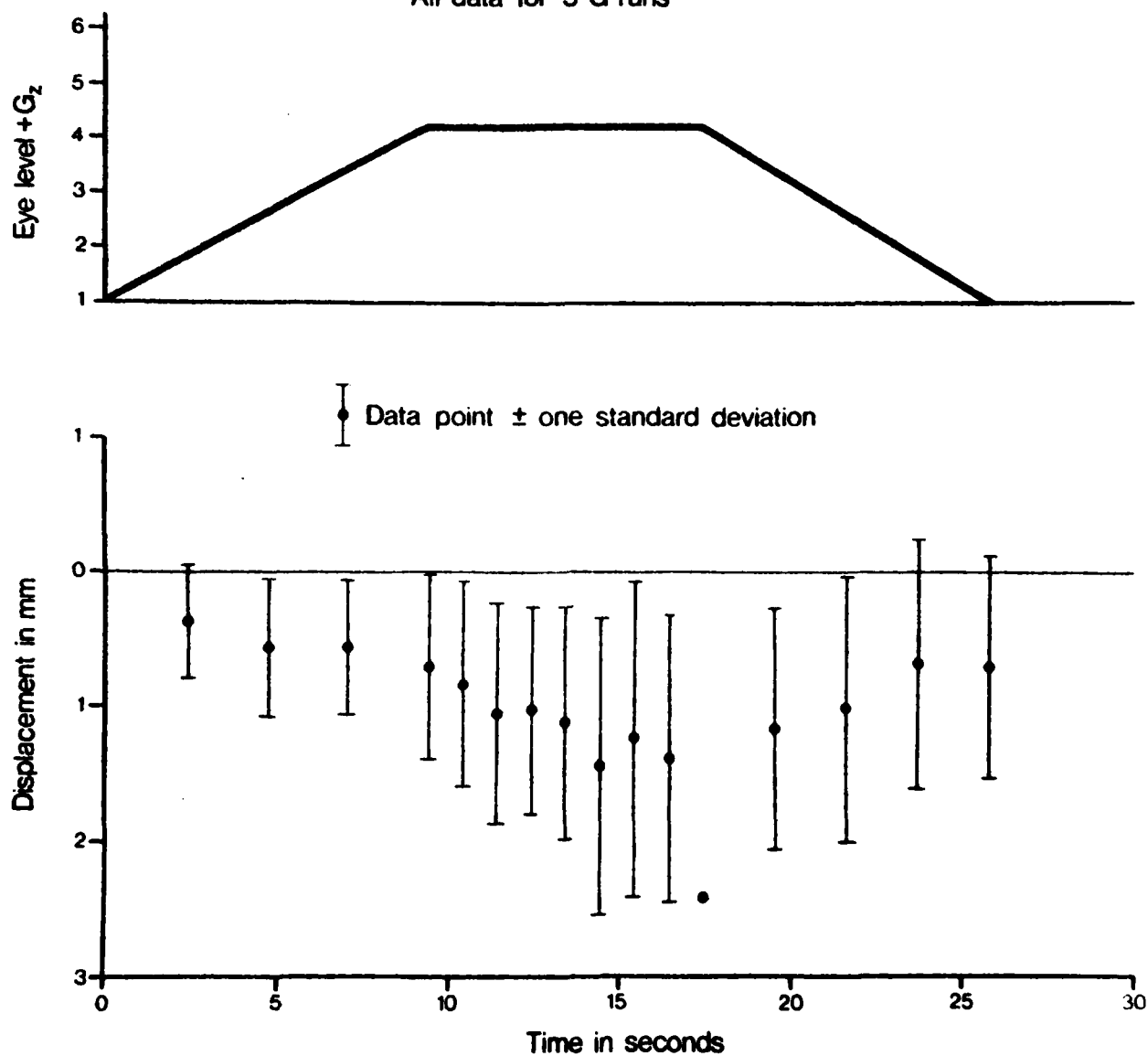
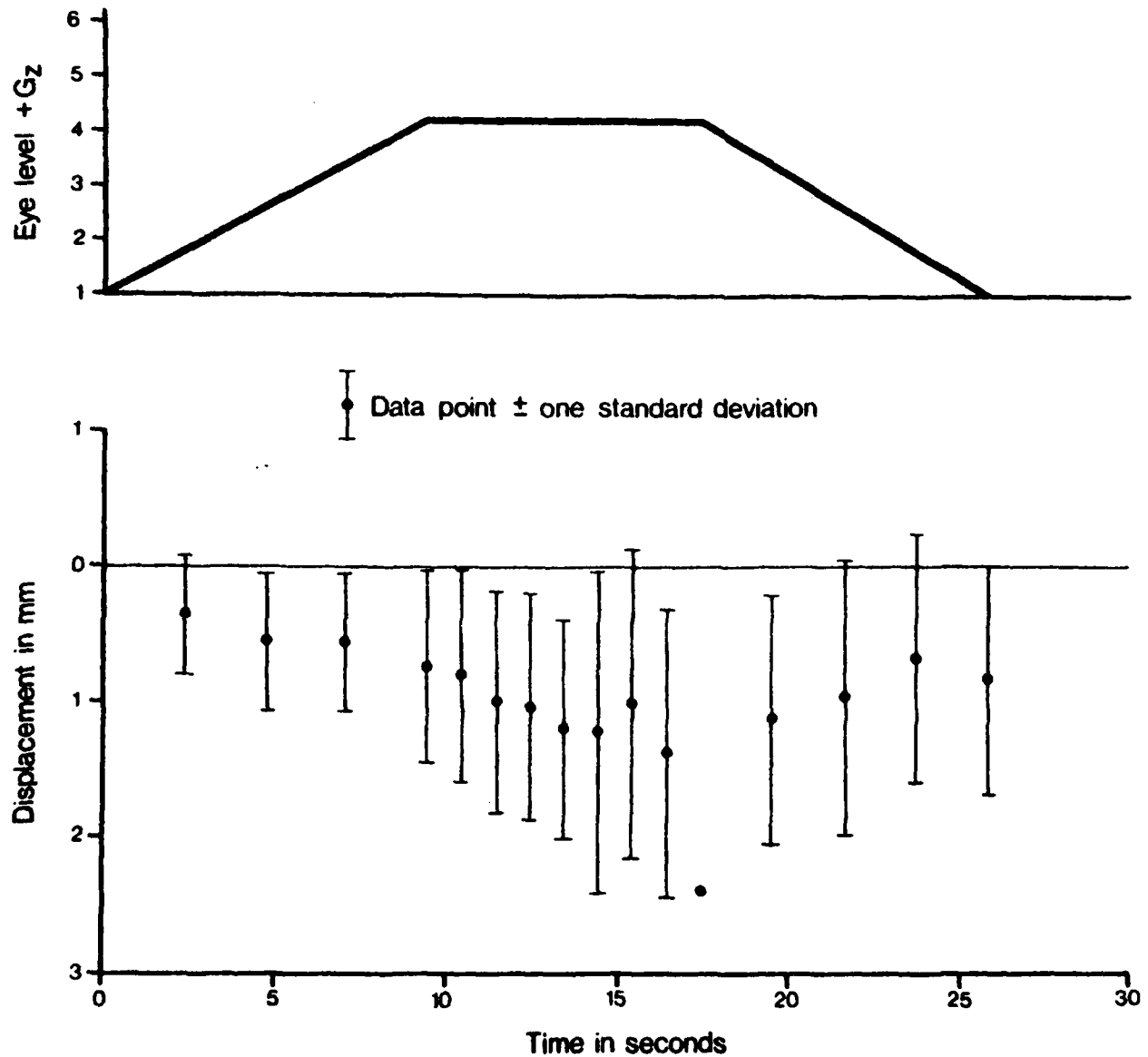


Figure 1. Downward movement of lenses with maximum eye level $+G_z$ of 4.2 and upward movement upon reduction of G . Upward movement was influenced by blinking and facial tensing.

Figure 2

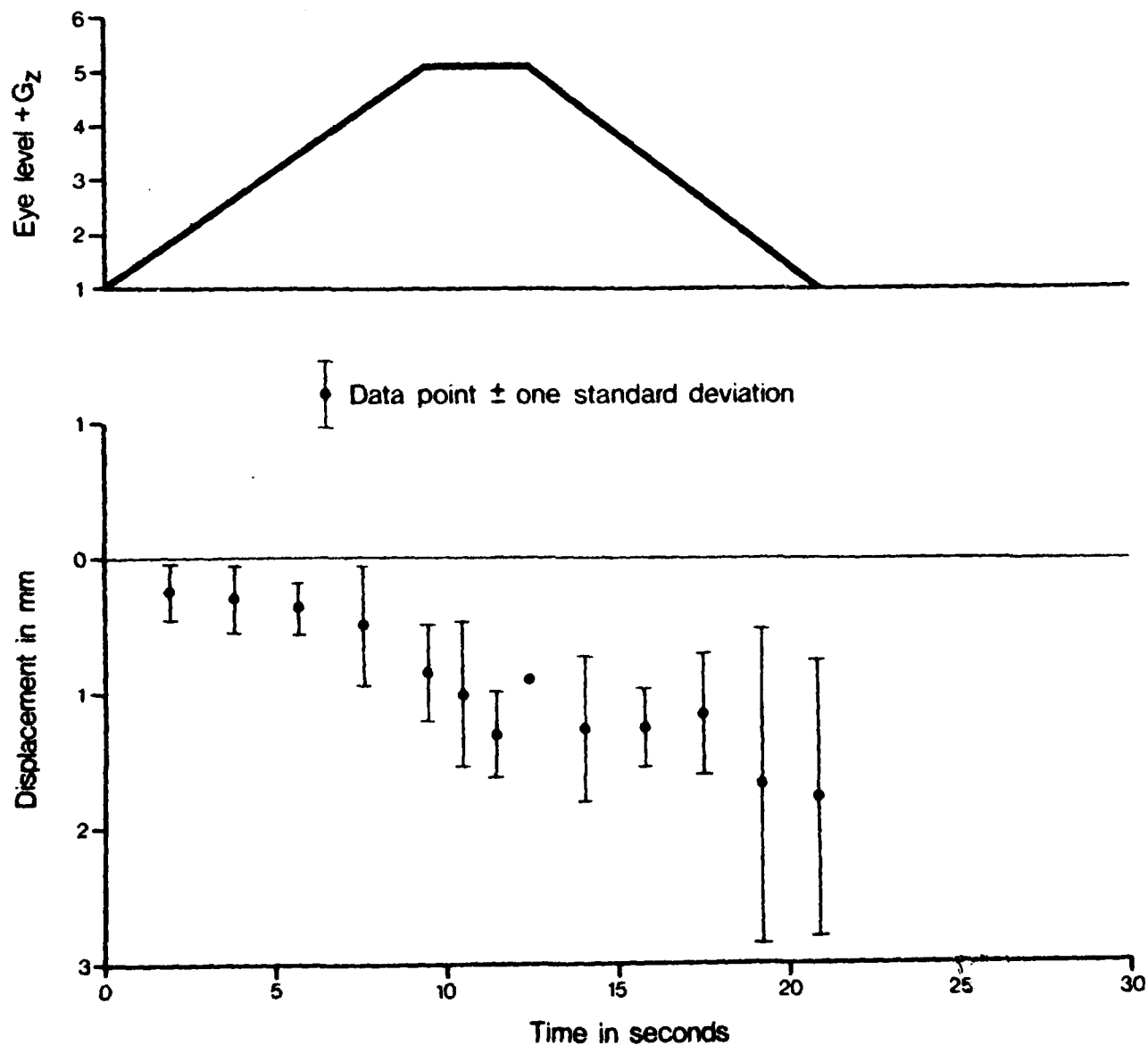
DISPLACEMENT OF CONTACT LENSES WITH $+G_z$

Data graded good or better for all 5 G runs



Downward movement of lenses with maximum eye level $+G_z$ of 4.2 and upward movement upon reduction of G where position of lenses were well defined.

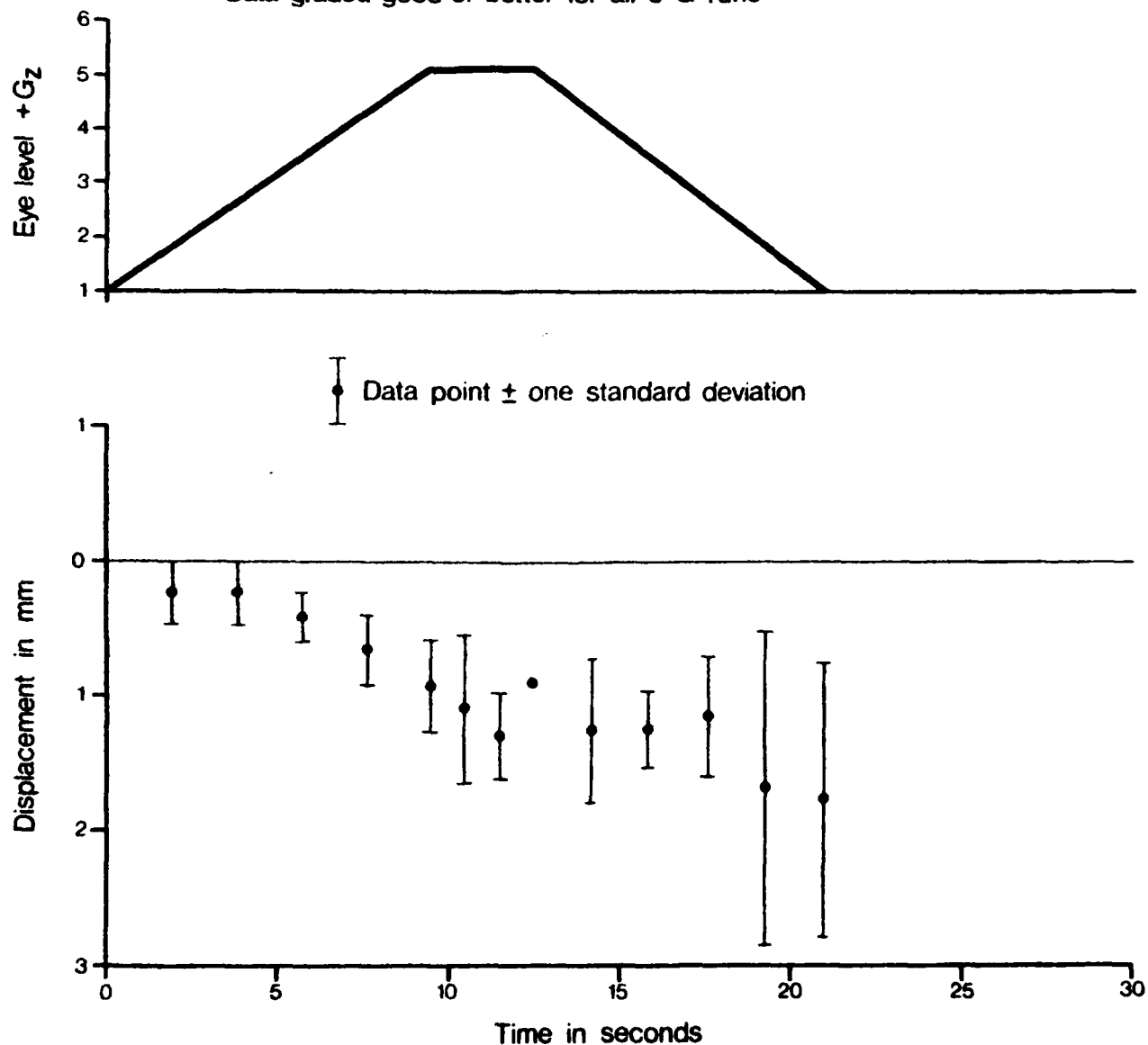
Figure 3 **DISPLACEMENT OF CONTACT LENSES WITH +G_Z**
All data for 6 G runs



Downward movement of lenses with maximum eye level G of 5.1 and non-upward movement upon reduction of G. The non-return of the lenses was attributed to the lack of blinking and facial tensing by the subject.

Figure 4 **DISPLACEMENT OF CONTACT LENSES WITH $+G_z$**

Data graded good or better for all 6 G runs



Downward movement of lenses with maximum eye level G of 5.1 and non-upward movement upon reduction of G where position of lenses were well defined.